SIMULATION OF EVACUATION, ESCAPE AND RESCUE

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Synopsis: DNV Technica has developed a program capable of simulating both evacuation and rescue operations offshore. All parameters that are significant to the outcome of escape and rescue operations can be taken into account. Input to PEER is a description (or "picture") of the offshore installation, its escape and rescue facilities and the environmental climate on the location. The program is ideally suited for comparing alternative systems, under variety of environmental conditions and accident scenarios.

Key words: Offshore evacuation, escape, rescue, simulation program.

INTRODUCTION

PEER is a program for simulation of evacuation and rescue operations offshore.

The objectives has been to facilitate accurate performance predictions for evacuation and rescue systems. This includes facilities for comparison of different escape and rescue concepts and modification alternatives. Sensitivity analysis is easily performed.

All parameters that are significant (more than 120 different types of variables) to the outcome of escape and rescue operations can be taken into account in the simulation model. Input to PEER is a description (or "picture") of the offshore installation, its escape and rescue facilities and the environmental climate on the location.

Due to the many factors influencing on the success of evacuation and rescue operations offshore it is necessary to utilise the Monte Carlo simulation technique to be able to perform a complete quantified assessment.

A major advantage of the program is that there is a direct coupling between the evacuation simulation and the rescue operation simulation. This ensures that prevailing environmental conditions are treated consistently.

The paper gives, a brief outline of the program together with a discussion of some important lessons learned from applications on various projects.

MAIN PARAMETERS

The main parameters are:

The Platform	Escape means	Rescue means	Environment
Geometry	Helicopters	Standby vessels	Longterm wave & wind statistics
Personnel distribution	Bridge	Fast rescue boats	Pierson-Moskowitz wave spectrum
Accident scenarios	GEMEVAC	Helicopters	Stochastic wind model
Location of escape means	SES-4	Insulated survival suits	Visibility statistics
	Freefall lifeboats	Non-insulated suits	Current
	Davit launched lifeboats	Lifejackets	Sea temperature statistics
	PROD lifeboats		
	SES-2		
	Davit launched rafts		
	Throw-overboard rafts		
	Donuts		
	Ropes and ladders		

For all evacuation and rescue means the availability, capacity and reliability is calculated as a function of acting accident scenario and environment.

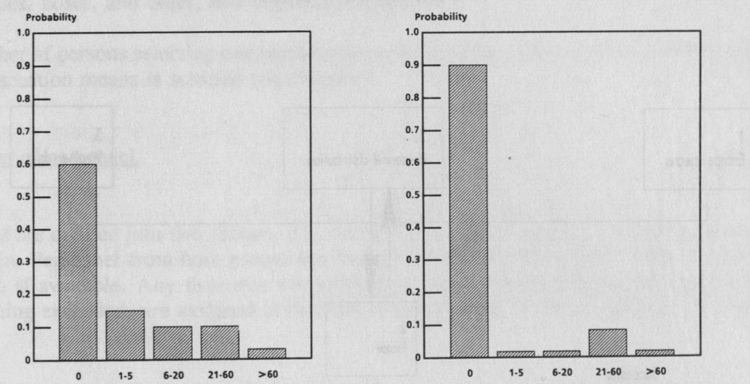
METHODS

All failure modes of the various items of equipment are identified. The probability of occurrence is quantified on the basis of the best available detailed studies and databases like Offshore Reliability Data (OREDA) and Worldwide Offshore Accident Databank (WOAD). The motion and displacement of lifeboats during launching and escape are calculated by numerical time-step simulation of the partial differential equations for motion.

Long term wind and wave distribution together with other relevant environmental parameters for the given location are applied. The short-term seastate is simulated by decomposing the wave spectrum. Overall results are calculated by applying the Monte Carlo simulation technique.

RESULTS

A large variety of results can be derived from the program. Typically, the performance of an evacuation and rescue system is expressed by a probability distribution for potential loss of lives.



Example: Fatality probability distributions for two alternative escape systems.

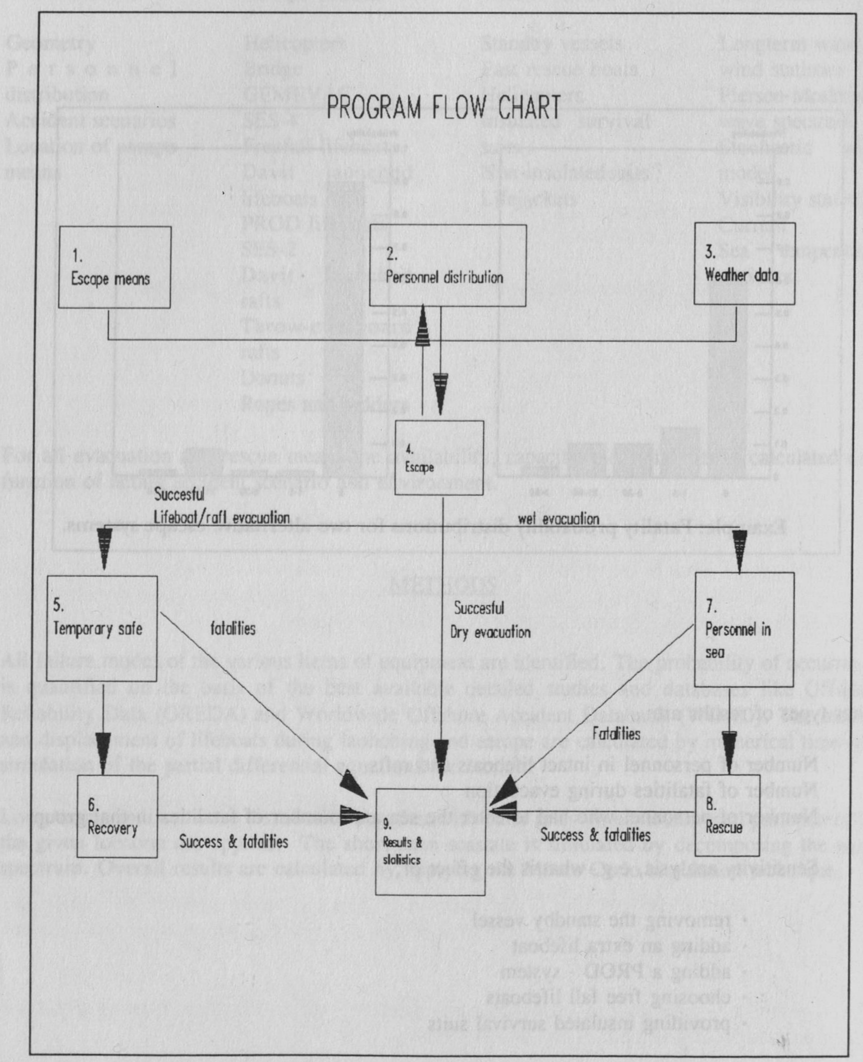
Other types of results are:

- Number of personnel in intact lifeboats and rafts
- Number of fatalities during evacuation
- Number of personnel who had to enter the sea and number of fatalities in that group

- Sensitivity analysis, e.g. what is the effect of;
    - removing the standby vessel
    - adding an extra lifeboat
    - adding a PROD - system
    - choosing free fall lifeboats
    - providing insulated survival suits

DATA FLOW

The PEER overall/first level dataflow can be described in the following flow chart:



Means of evacuation

The user specifies the types of evacuation means, capacity, location and other technical characteristics such as hooktype, engine power etc. for the various means.

For each person, the available means of evacuation is established, with the following priorities:

a) Dry evacuation means
b) Lifeboats
c) Wet evacuation
d) Ladders
e) Ropes, hoses, and other, non defined, possibilities

If the number of persons selecting one means of evacuation exceeds the capacity, a lower priority type of evacuation means is selected automatically.

Distribution of personnel.

Evacuees are divided into two groups, e.g. one in the northern and one in the southern part of the platform. Personnel from both groups are then assigned evacuation means, starting with dry evacuation, if available. Any evacuees not gaining access to the highest priority means due to capacity being exceeded, are assigned to the next category until all are evacuated, or escaped to the sea.

Weather data.

Weather data are required for the actual platform location. One set of environmental data consist of:

- Wave height, wave period and wave spectrum
- Wind and wind direction
- Current
- Sea temperature (monthly mean)
- Visibility (day/night, fog)

Correlations between the various parameters are taken into account.

The acting weather is randomly selected based on the input weather probability distributions and application of Monte Carlo simulation.

The effects of the environmental conditions are many, e.g.:

- Certain weather directions may cause lifeboats and liferafts to drift into an area with critical heat radiation on the surface or cause the boats/rafts to collide with the installation structure.
- The Fast Rescue Boats (FRB's) are not operational when the sea state is above a certain level.
- Fog conditions reduces the search and rescue efficiency.

All such effects are taken into account.

Evacuation.

The evacuation process is simulated separately for each evacuation means utilised. All parameters influencing on the success of escape is taken into account for each means. E.g. for lifeboats the following calculations are made:

- Probability that the boat can not be launched
- Probability that the boat becomes stuck or free falls during descent
- Probability of delayed or no hook-release
- Probability of engine not starting
- Probability of being hit by a breaking wave causing hazardous collision with the structure
- Probability of collision with structure due to other reasons.

The latter is calculated by simulating wind and wave forces acting on lifeboat, taking into account the pendulum motion during descent, manouverability etc.

As a result from the evacuation simulation the number of personnel in each of the following categories are given:

- personnel dry evacuated
- personnel in a temporary safe condition onboard intact lifeboats and rafts
- personnel in the sea;
    - alive with suit
    - dead with suit
    - alive with lifejacket
    - dead with lifejacket
    - alive without floating support
    - dead without floating support

Rescue.

Rescue is defined as being picked up from the sea by fast rescue boat (FRB), standby vessel or helicopter. The pick up rate is defined as the number of persons being picked up for a given means of rescue, per hour.

The pickup rate is calculated as a function of mobilisation time, seastate, visibility, spread of persons in the sea time needed for transit and load off when the capacity of rescue vehicle is reached, etc.

The drift and subsequent spread of persons in the sea are taken into account.

The time for survival in the sea is given as a function of sea temperature, seastate and personal protection.

It is assumed that initially (t=0), a number of persons are afloat at random position within a limited area as defined in the input. They immediately start to drift under influence of the general ocean current and wind generated current. Detection is based on visual observation of the sea. Clearly visibility is a parameter. Also the sea surface conditions are of importance, as choppy seas makes detection difficult.

It is assumed that the rescue vehicles operates in a logic manner not tracking the same area.

Recovery.

Fatalities due to hazards during retrieval of personnel from lifeboat and liferaft and direct from the sea are given as a function of seastate. The probability that the recovery is attempted from lifeboat in severe weather conditions is given as input.

Results.

One iteration through the program represent one possible outcome of an evacuation for a given weather condition and accident scenario.

The number of fatalities calculated in each iteration is noted together with up to five other parameters characterising the environmental condition or other parameters of interest in simulation for that iteration.

Then a new iteration is performed using the Monte Carlo simulation technique.

The number of iterations are selected so that the average number of fatalities are converging. Normally 1000 iterations is necessary to reach converging result.

LESSONS LEARNED

In this section some important lessons learned from application of the PEER program on various projects are given.

There are four main items which should be adequately dealt with in order to obtain a good evacuation and rescue system:

1. Decision making criteria and training.
2. Availability and capacity during representative accident scenarios.
3. Reliability of evacuation during severe weather conditions.
4. The rescue system should suit the needs of the evacuation system.

Decision making

The process of deciding whether to evacuate or not is critical. Studies has shown that both too frequent evacuations and too late decisions can increase the potential loss of lives. Proper decision criteria based on risk analysis should be available as a guideline for the OIM.

Availability and capacity

A set of representative credible accident scenarios should be defined based on risk analysis. Based on these "dimentioning" events the optimal location and protection of the evacuation means should be selected.

Helicopters will normally not be available as evacuation means during actual accidents where evacuation is required. Normally lifeboats are the primary evacuation means. the location and protection of the lifeboats should be carefully considered. This can be done as follows:

- For each representative accidental event there should be at least one lifeboat seat available to each person. For the lifeboats by the TSR there should be at least one spare lifeboat available in case of failure to start or launch one of the other boats.
- If fire on sea is a credible accident scenario, special protection of the lifeboat is necessary. In such cases measures should be taken to avoid that smoke hinders embarkation.

Reliability

The ability of the evacuation means to safely clear the installation structure during adverse weather conditions is the most important factor. For conventional lifeboats a generous free distance to the structure is necessary. By utilising the Pr.O.D or other enhancing methods the overhang can be reduced. However, the first order wave induced motions will still have to be taken into account.

Free fall lifeboats represent technology which has been proven in training, however, they have never been used in a serious accident. Technical reliability is still considered good and the uncertainty is small for the launching and escape phase also during severe weather conditions. This is partly due to the fairly simple launch system.

Dry evacuation systems for transfer of personnel directly to a support vessel have a potential for further development. Especially for platforms located in remote areas where the facilities for a safe recovery of personnel from lifeboats on the sea is reduced. However it is noted that such systems may be rather expensive and will have limitations on maximum weatherconditions. Also the necessary time for evacuation will be relatively long.

Rescue

A general problem is the reduction in efficiency of the rescue system in severe weather conditions. At the same time the potential number of personnel in the sea increases. The FRB is in general the most efficient rescue tool. The maximum operational limitation of the FRB can be extended by locating the boat mid ship and by using a fast winch with constant tension or shock absorbing system. However, we feel that there is a need to develop efficient equipment which can be operated directly from the standby vessel in severe weather.

High quality survival suits for all evacuees are a major contribution to the safety of escape and evacuation. Such suits should be provided and located in a protected area for easy retrieval and proper donning of the suit.

The risks associated with recovery of personnel from intact lifeboats can be significant. Attention is required with respect to planning of such operations. Recovery of non injured personnel from intact lifeboats, in general, should not be performed until the sea is sufficiently calm before a safe transfer of personnel via FRB to the standby vessel is commenced. Seriously injured personnel can be recovered by helicopter in severe weather.